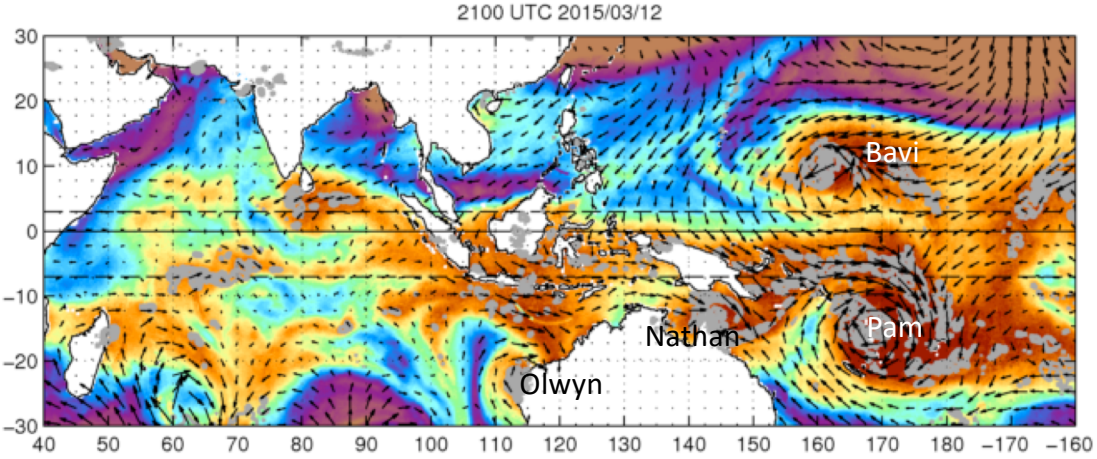
20 Years of TRMM-GPM Precipitation Tracking of the MJO and Its Implication for Tropical Weather and Climate

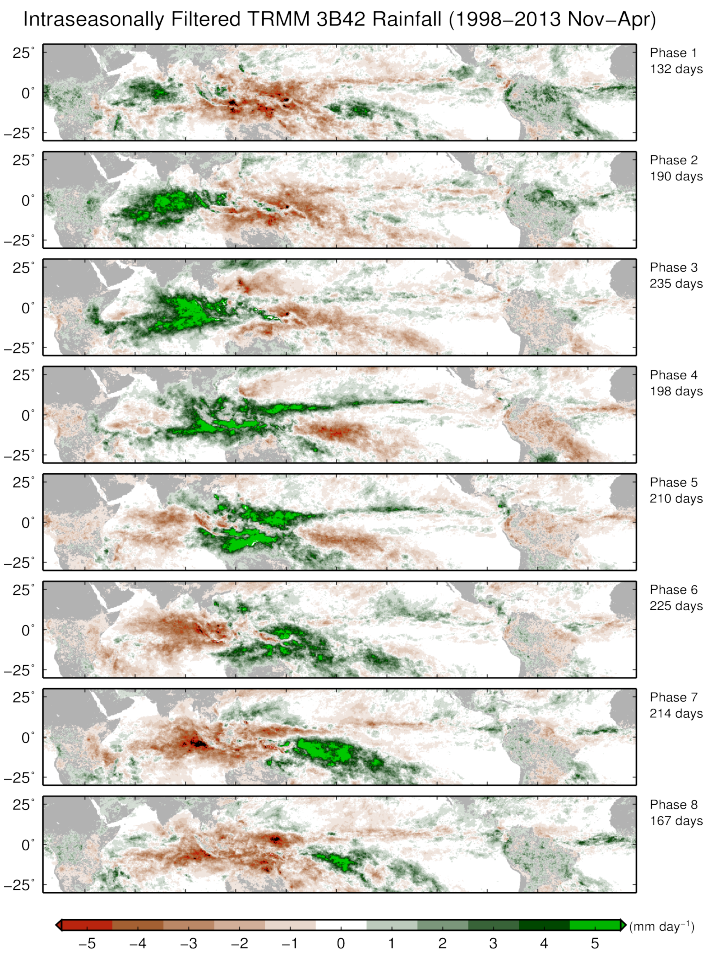
Shuyi S. Chen, Brandon Kerns, and Ajda Savarin
University of Washington
Hui Su, JPL (Poster # 240)

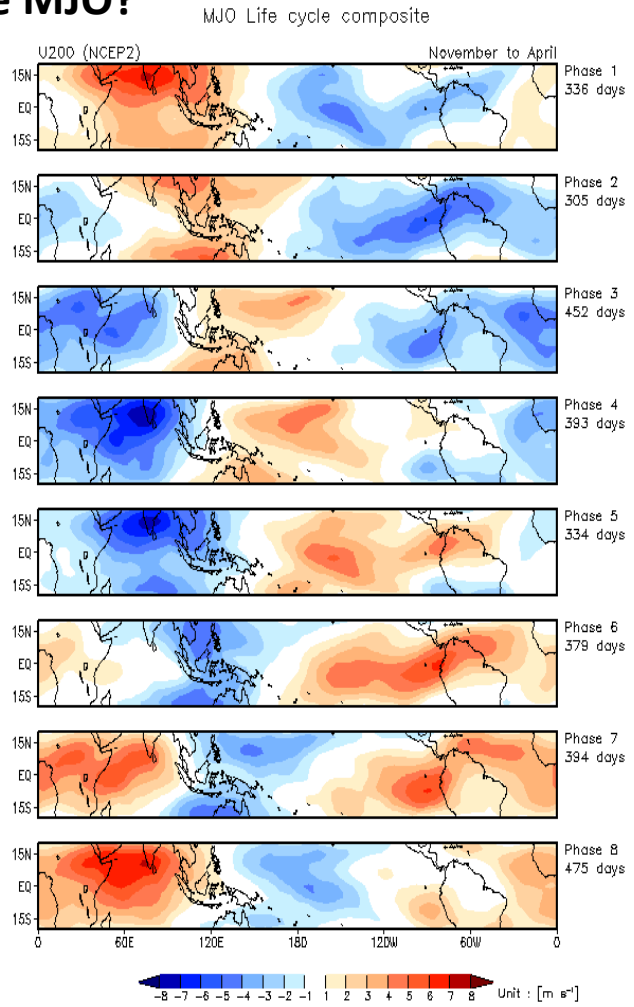


(PMM Science Team Meeting, Phoenix, AZ, 9-11 October 2018)

Hurricanes and Coupled Atmosphere-Ocean Systems

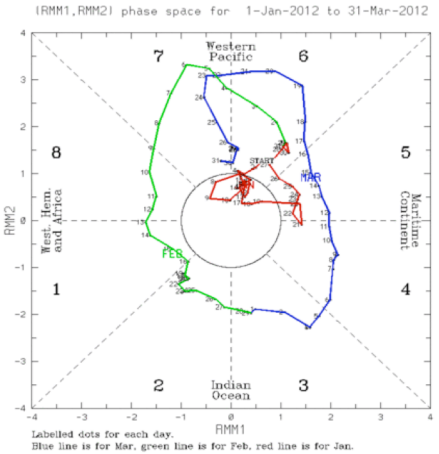
What is the MJO?





Realtime Multivariate MJO (RMM) Index

(Wheeler and Hendon, 2004)

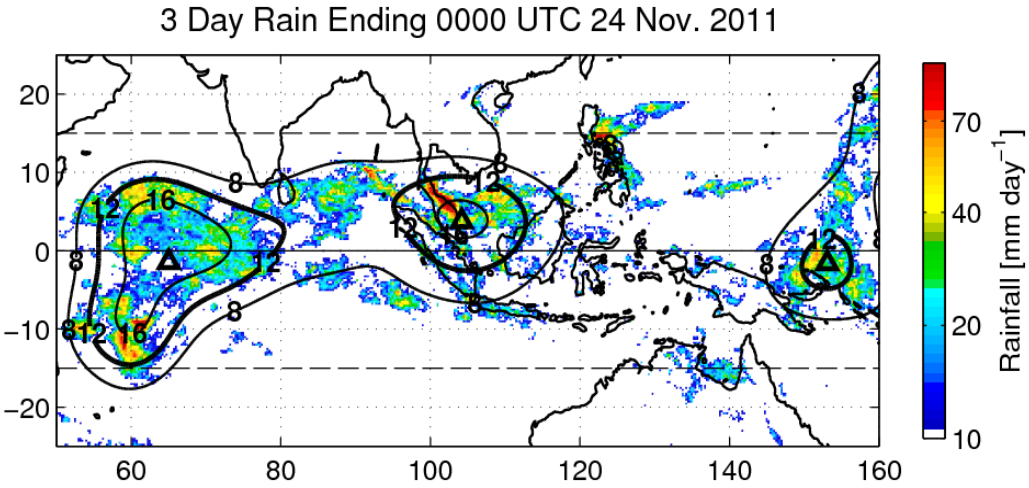


Limitations:

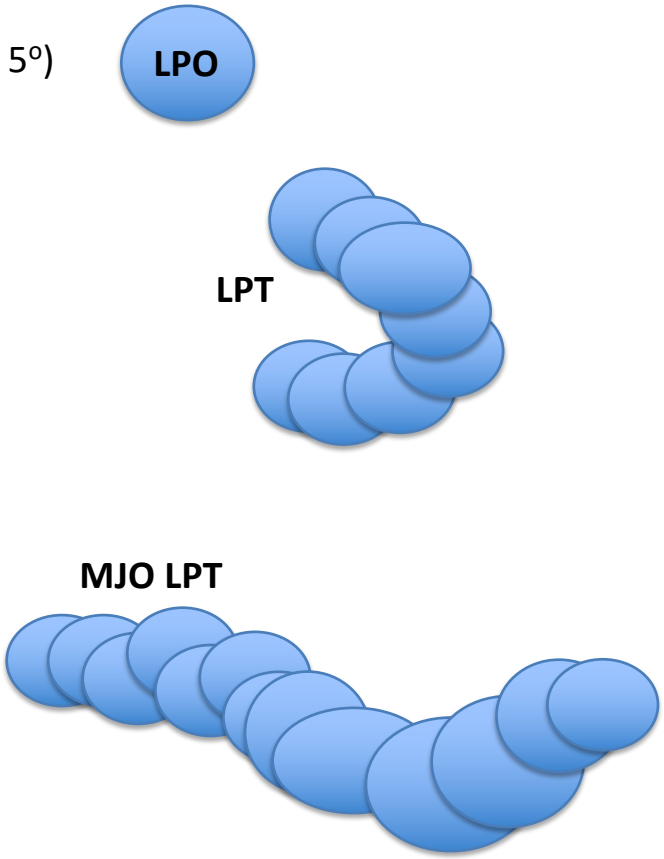
- No spatial & temporal info
- Not a direct representation of MJO precipitation
- Cannot be computed in regional models

Large-scale Precipitation Tracking (LPT):

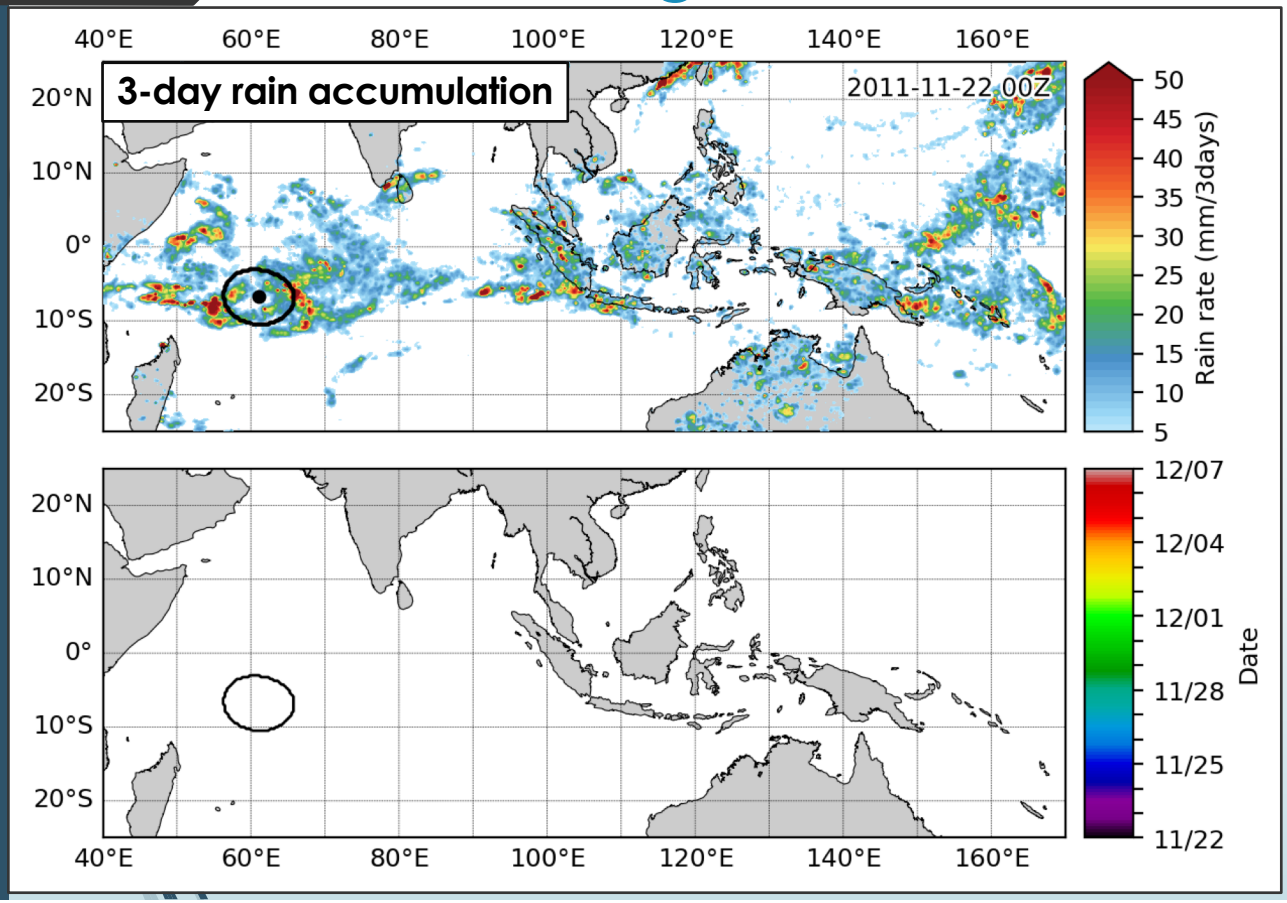
- TMPA 3B42 V7 data (3 hourly)
- **LP Object (LPO) :** 3-day accumulated rainfall with spatial filter (5° X 5°) area of > 12 mm day^{-1} (> 250,000 km^2)
- **LP Tracking (LPT)**: track LPO in time > 7 days
- **MJO LPT**: LPT > 10 days; eastward propagation speed > 0 m/s



Kerns and Chen (2016, JGR)

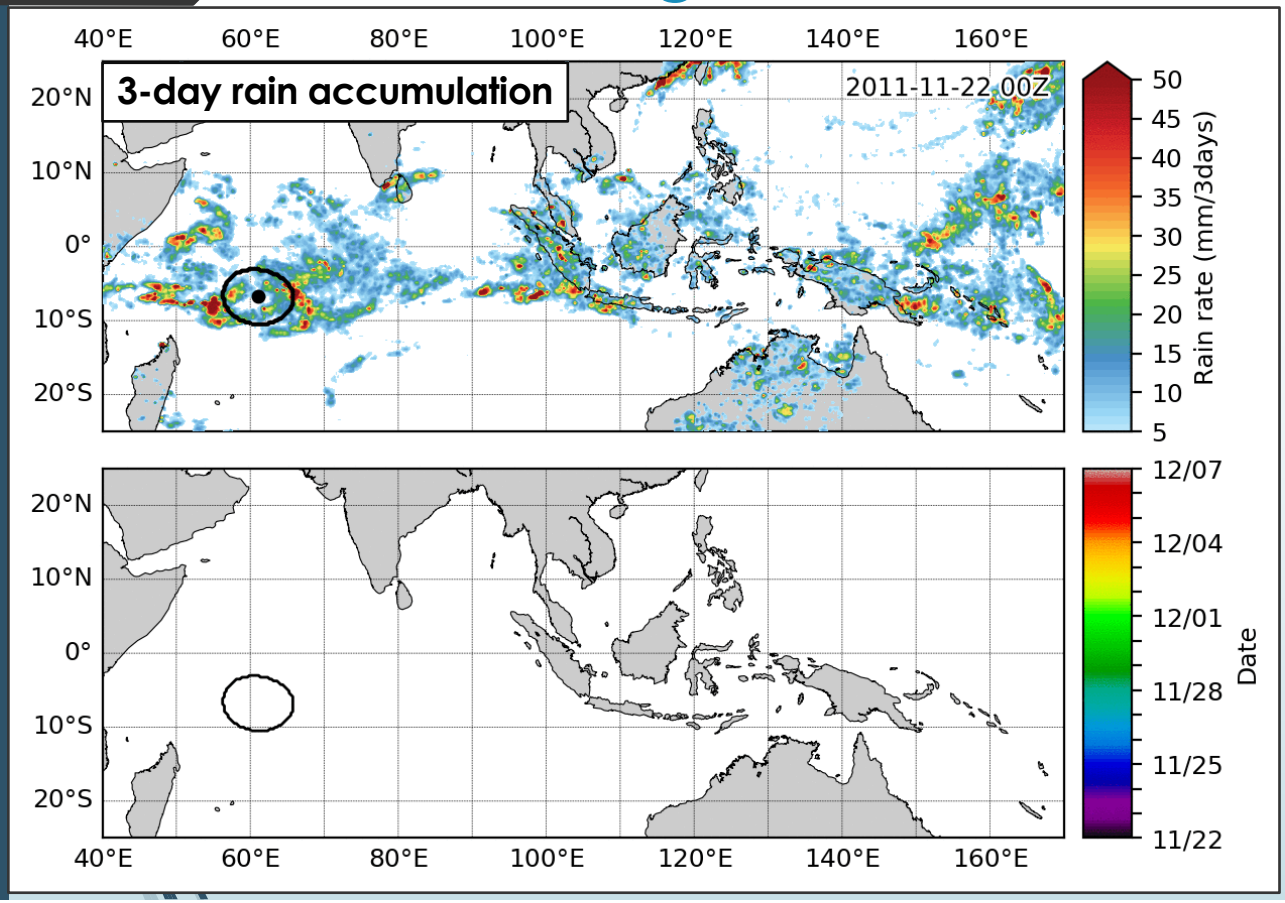


Tracking the MJO



- Traditional RMM index cannot provide spatial and temporal variation of the MJO.
- LPT is used to track MJO precipitation. **(Kerns and Chen 2016)**

Tracking the MJO



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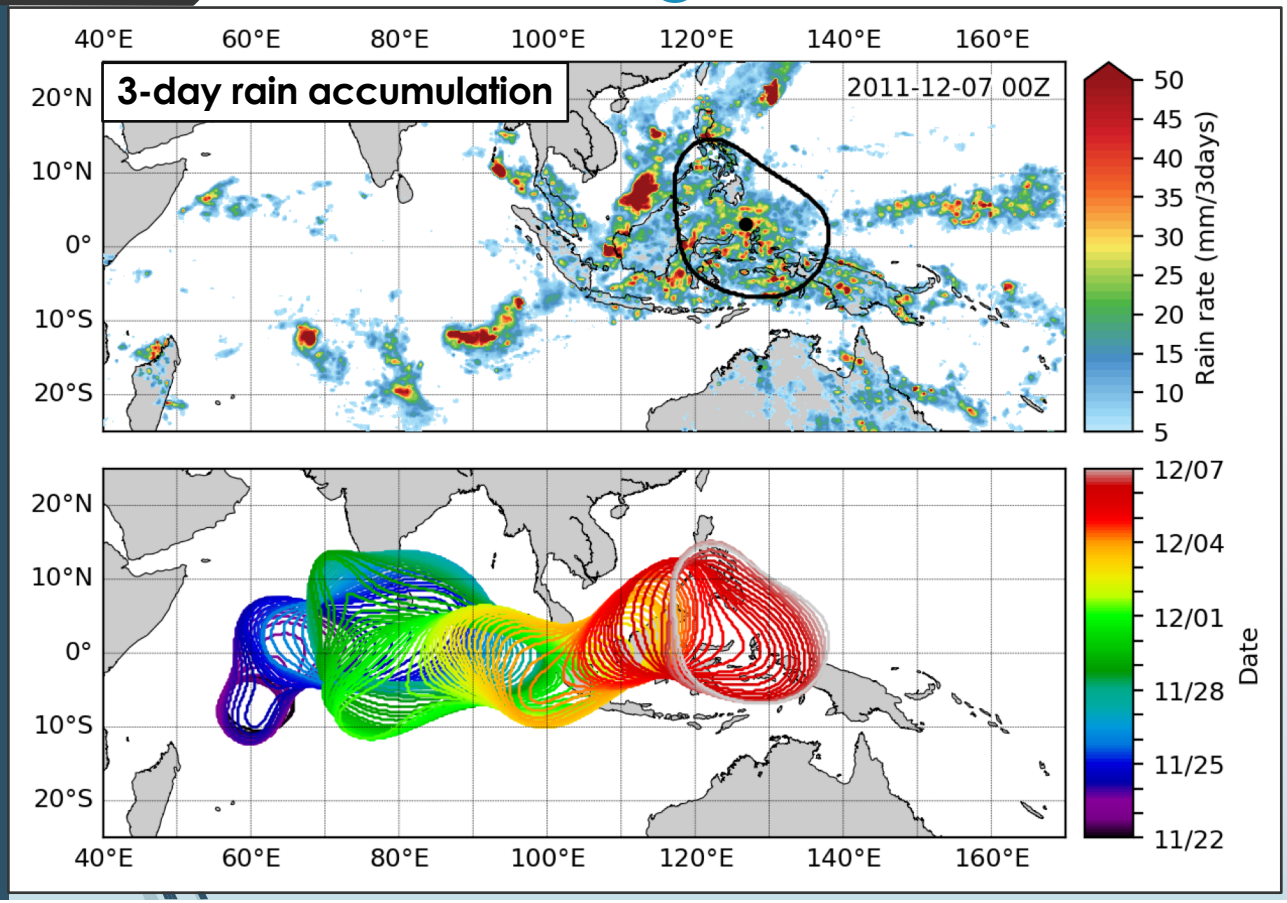
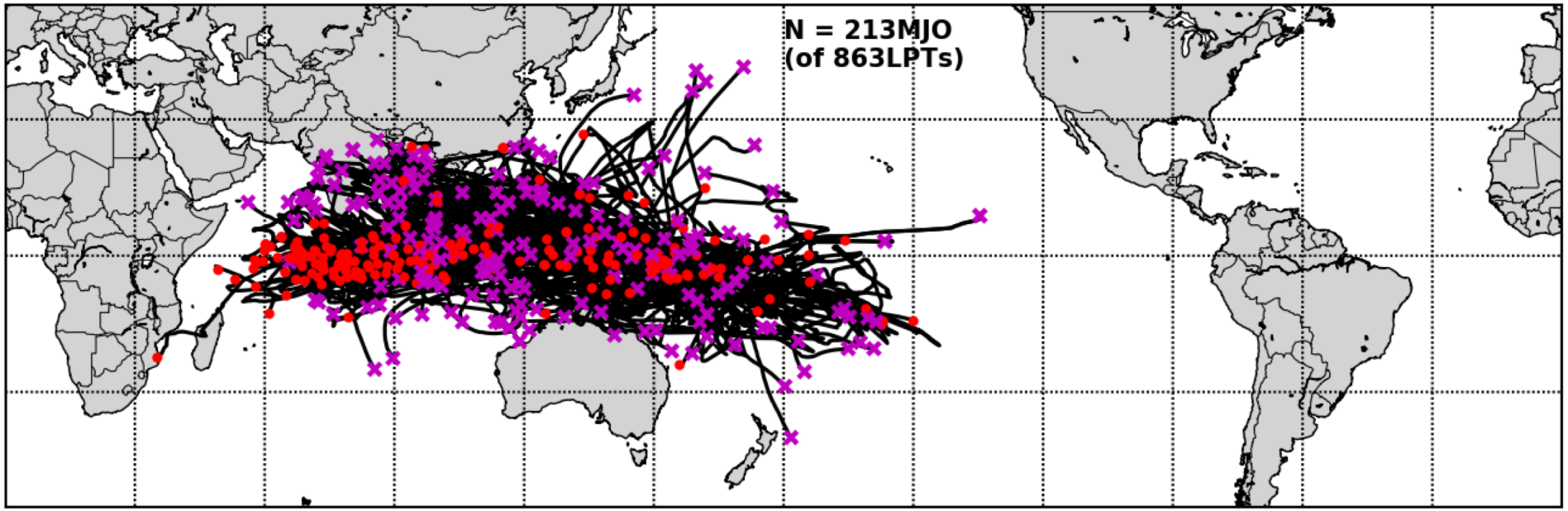
Tracking the MJO



- Traditional RMM index cannot provide spatial and temporal variation of the MJO.
- LPT is used to track MJO precipitation. **(Kerns and Chen 2016)**
- Challenge: majority of NWP and climate models cannot reproduce MJO precipitation patterns.

MJO LPT System Tracks: 1998 - 2018



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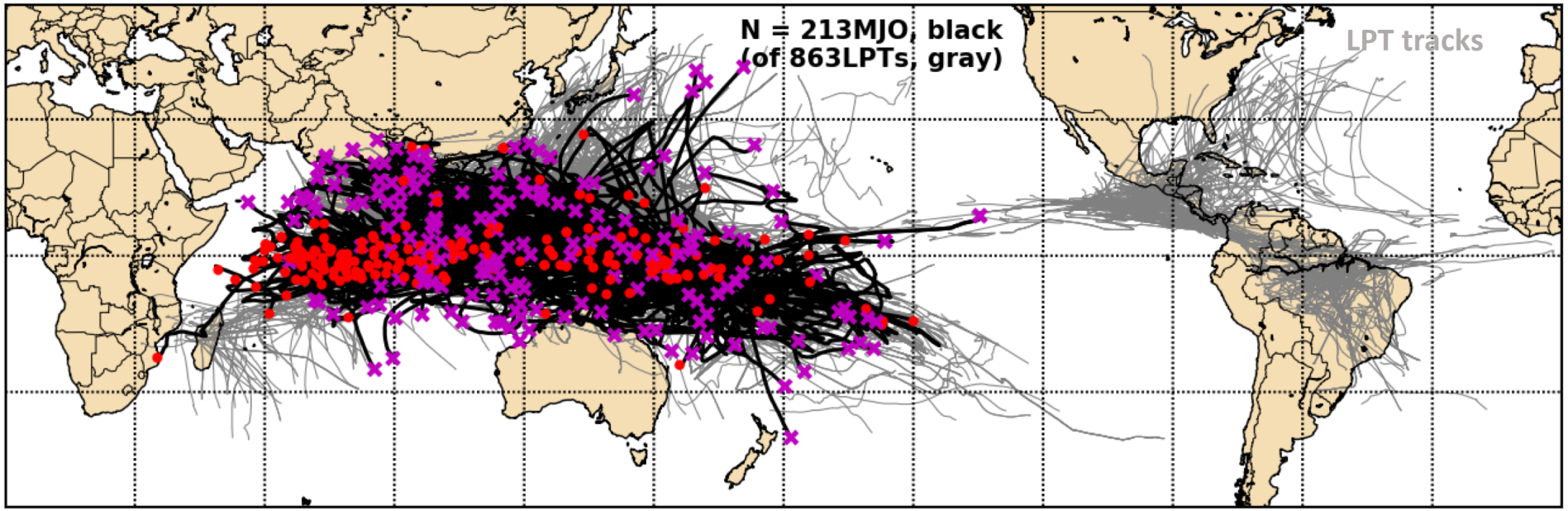
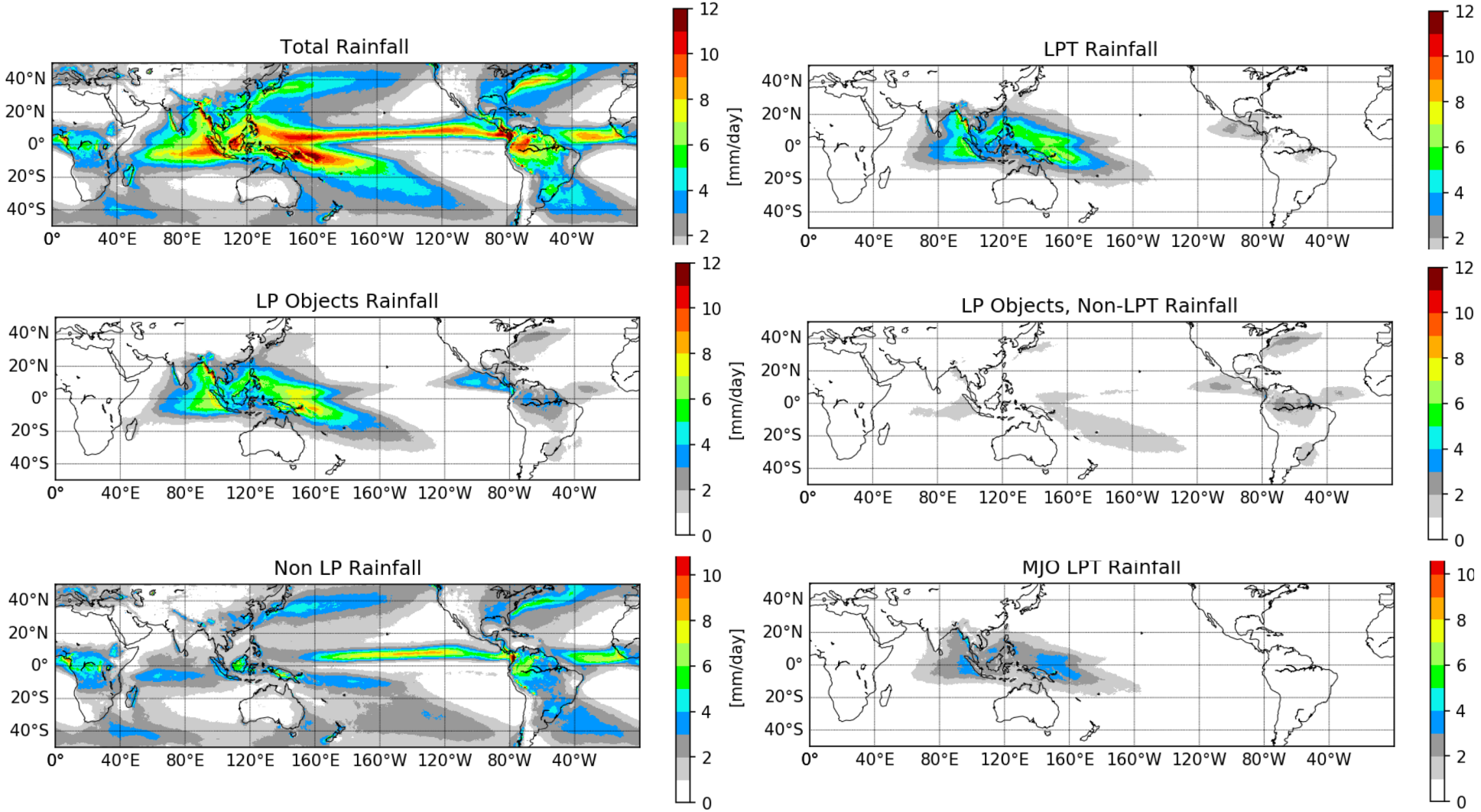
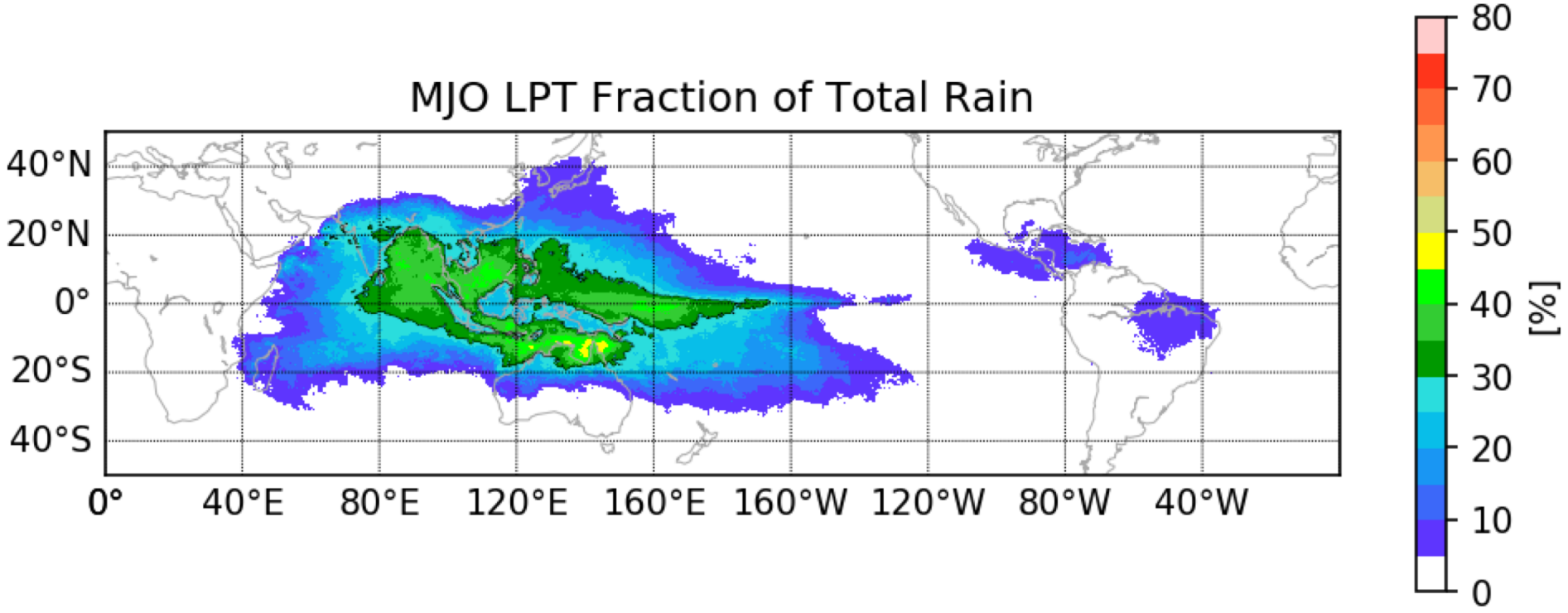
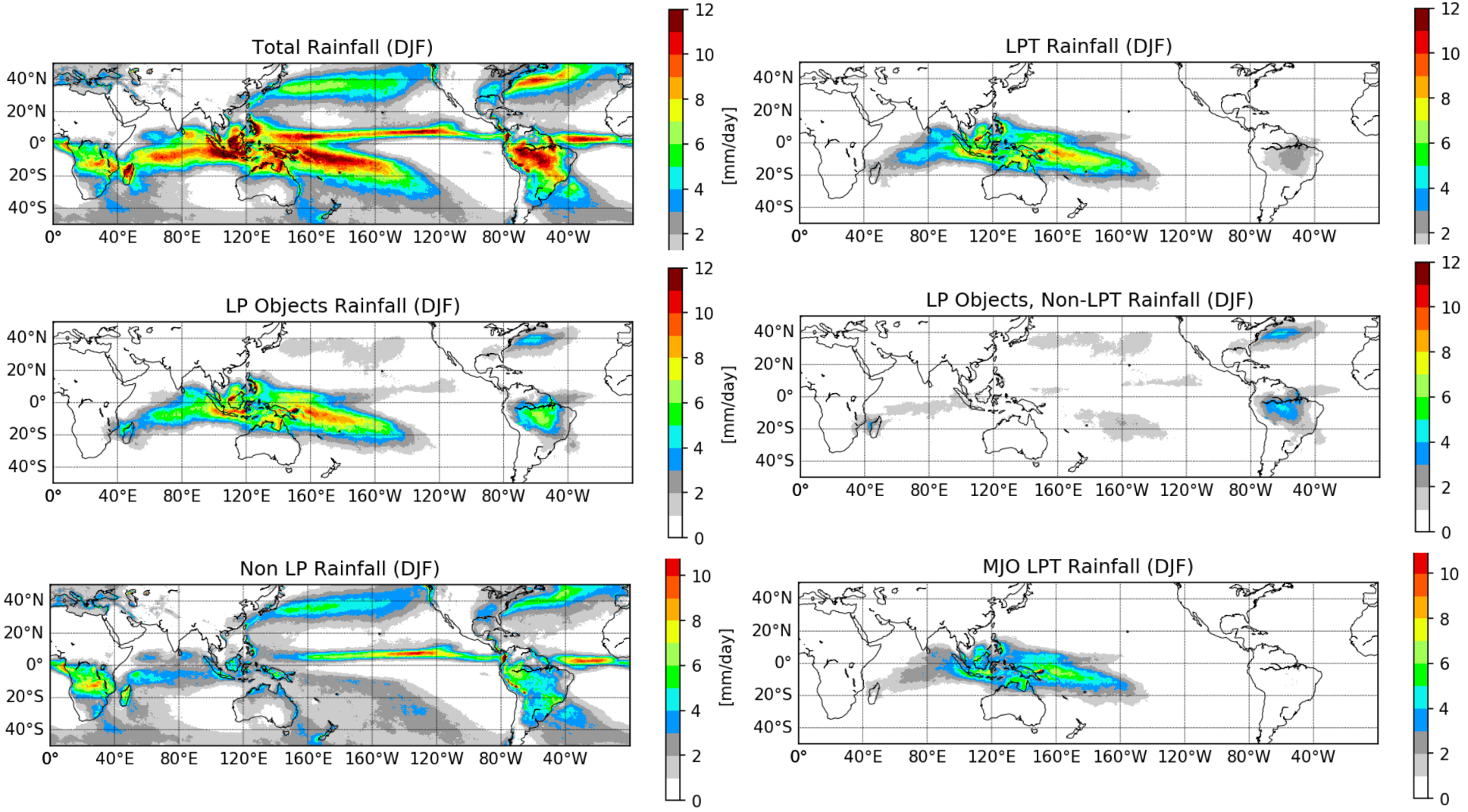
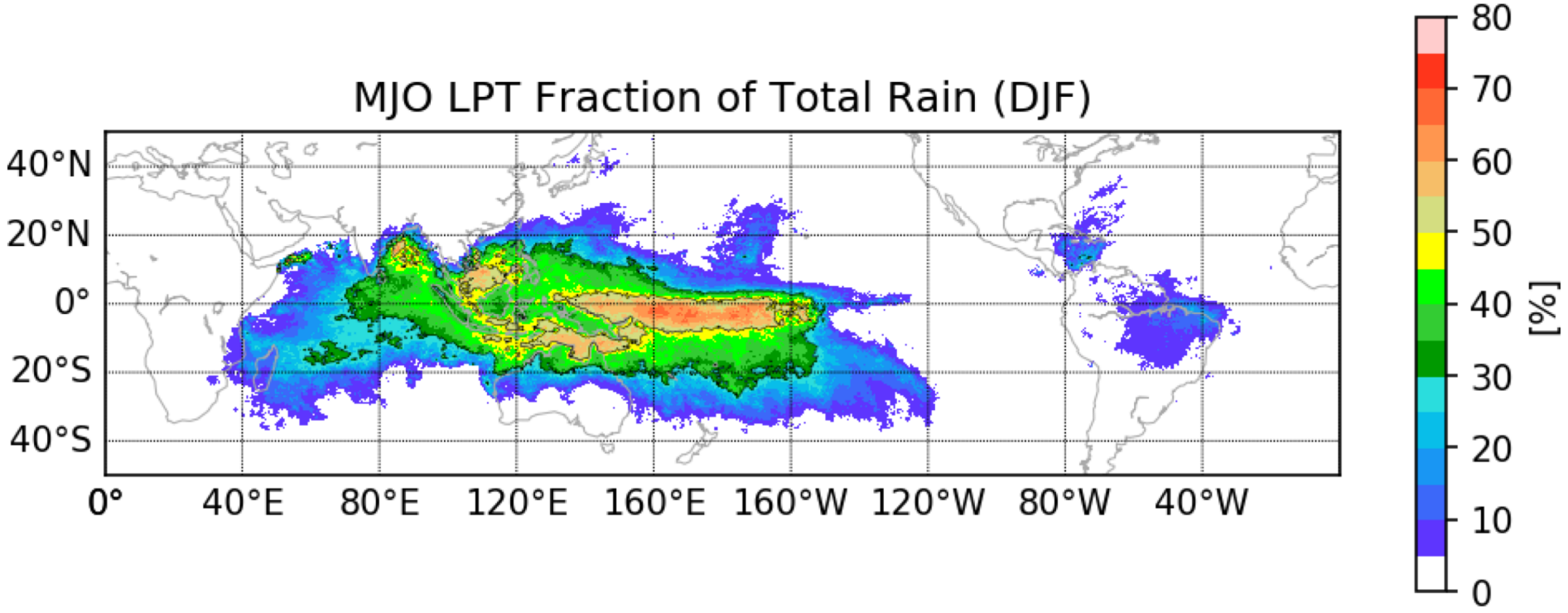


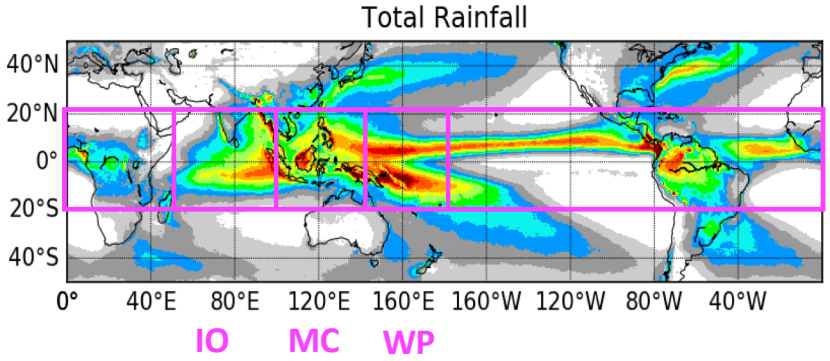

Total Rainfall
LPT Rainfall
LP Objects Rainfall
LP Objects, Non-LPT Rainfall
Non LP Rainfall
MJO LPT Rainfall
[mm/day]
40°N
20°N
0°
20°S
40°S
0°
40°E
80°E
120°E
160°E
160°W
120°W
80°W
40°W
0
2
4
6
8
10
12

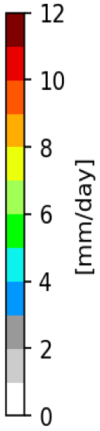

MJO LPT Fraction of Total Rain
40°N
20°N
0°
20°S
40°S
0°
40°E
80°E
120°E
160°E
160°W
120°W
80°W
40°W
80
70
60
50
40
30
20
10
0
[%]

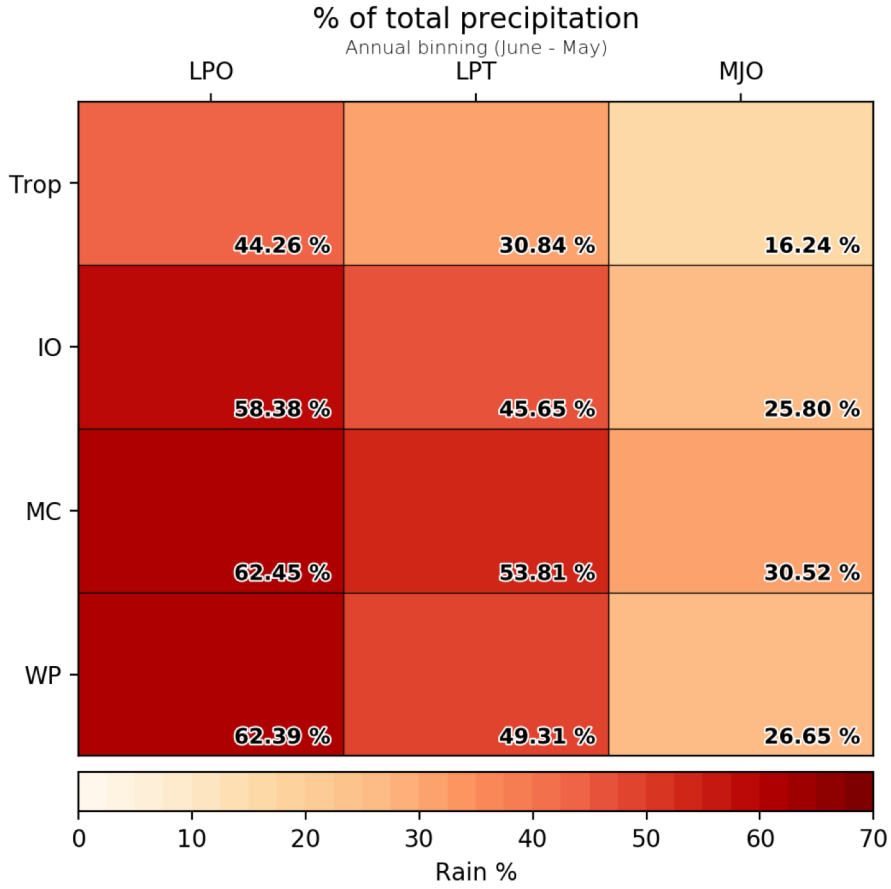

Total Rainfall (DJF)
LPT Rainfall (DJF)
LP Objects Rainfall (DJF)
LP Objects, Non-LPT Rainfall (DJF)
Non LP Rainfall (DJF)
MJO LPT Rainfall (DJF)
[mm/day]
40°N
20°N
0°
20°S
40°S
0°
40°E
80°E
120°E
160°E
160°W
120°W
80°W
40°W
0
2
4
6
8
10
12


MJO LPT Fraction of Total Rain (DJF)
40°N
20°N
0°
20°S
40°S
0°
40°E
80°E
120°E
160°E
160°W
120°W
80°W
40°W
80
70
60
50
40
30
20
10
0
[%]

Contribution of Large-scale Precipitation to Total Rainfall

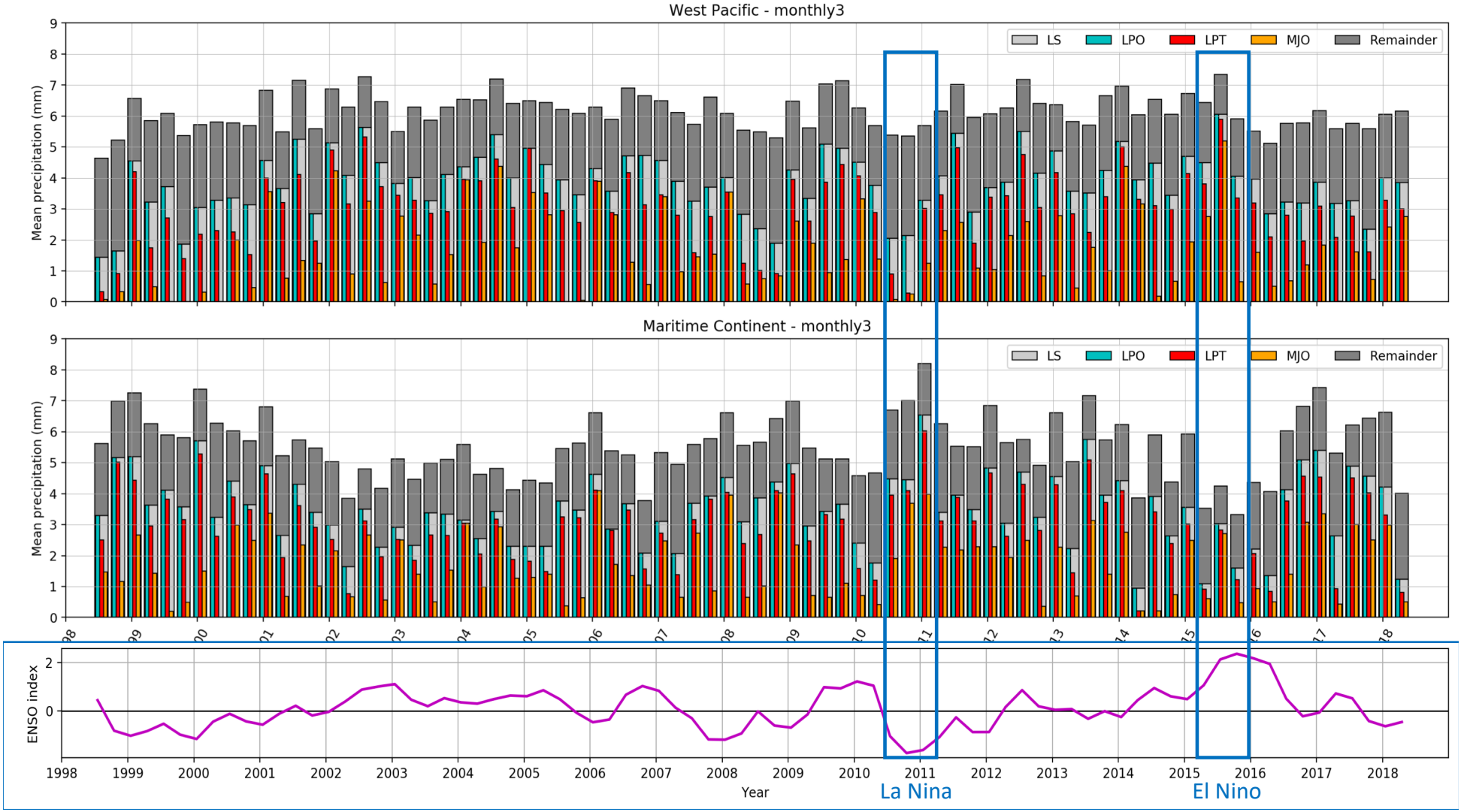


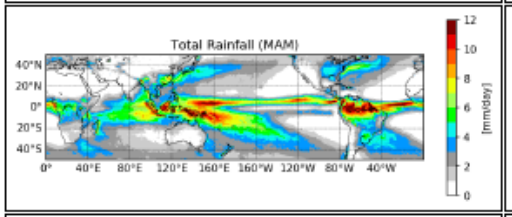
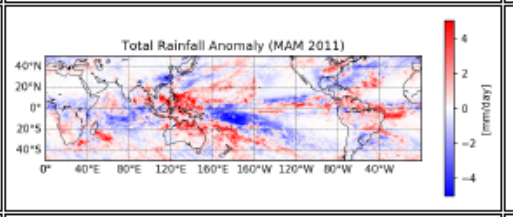
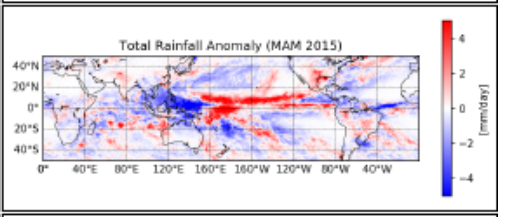
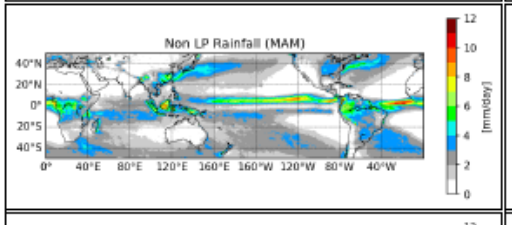
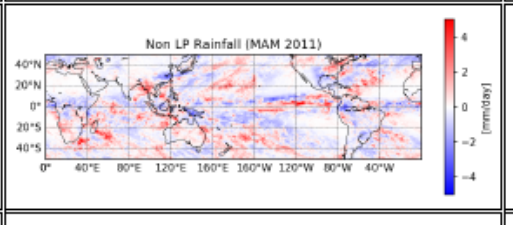
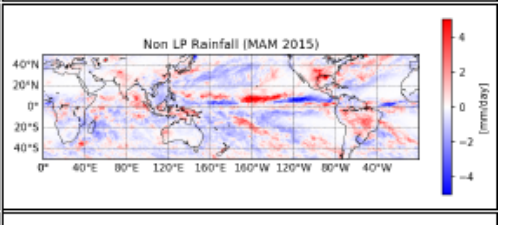
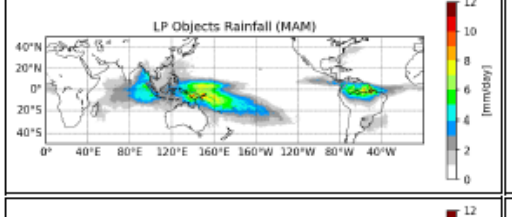
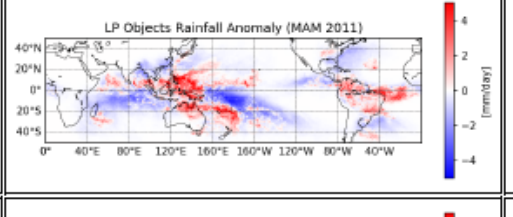
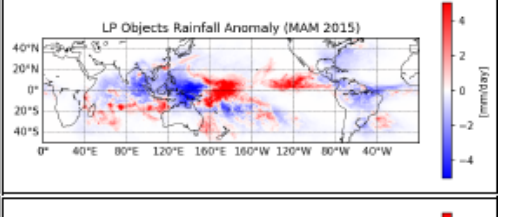
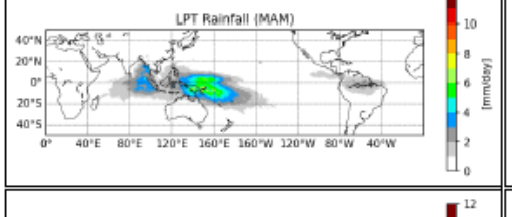
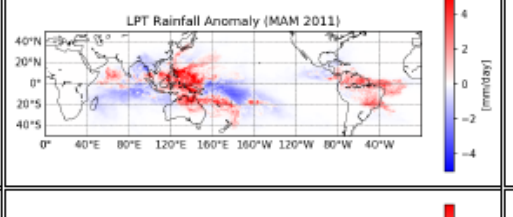
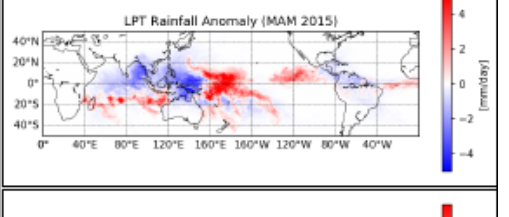
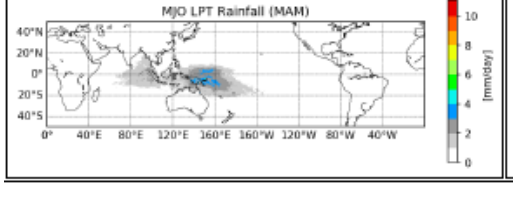
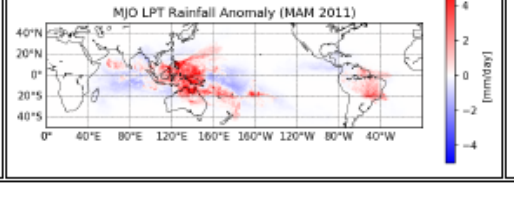
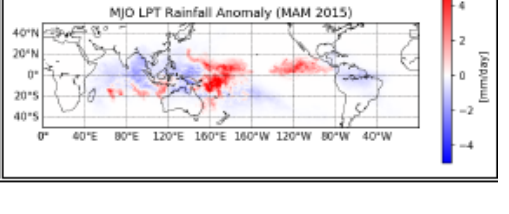




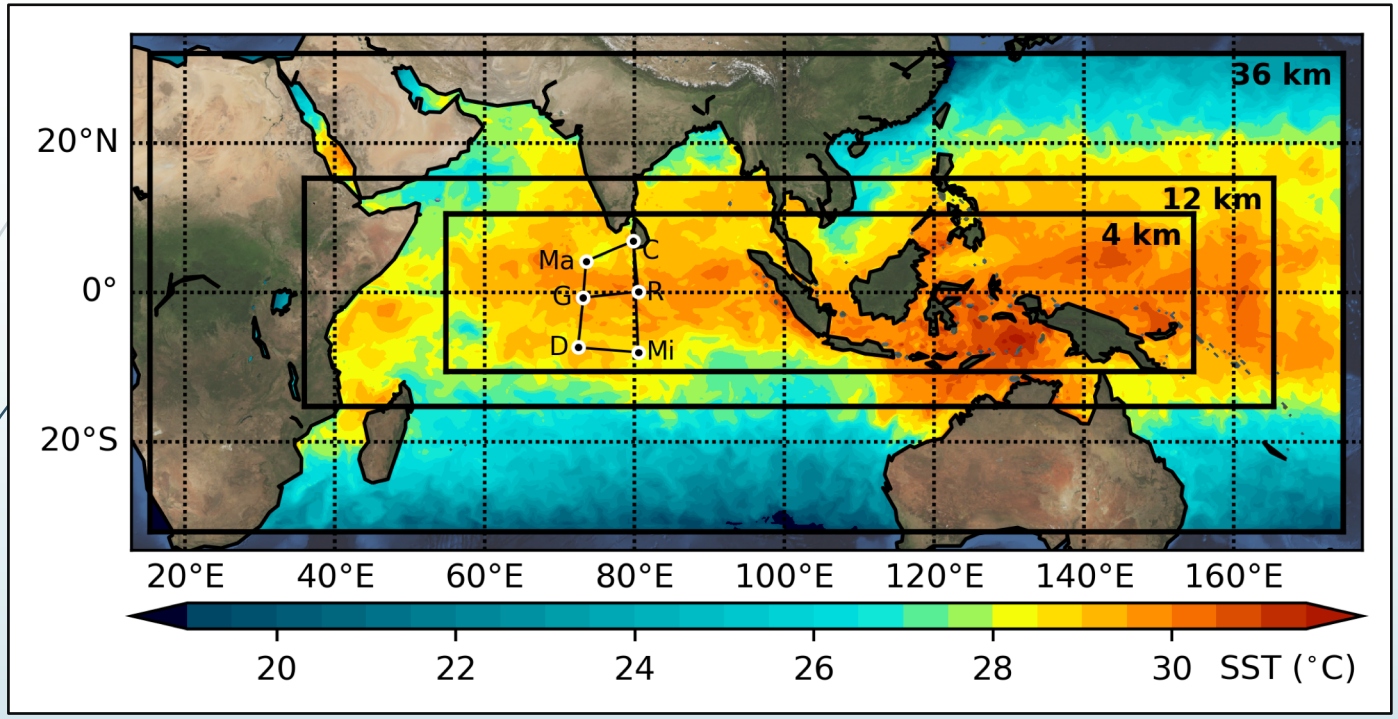
Global mean = 2.82 mm/day
LPT = 0.55 mm/day (20%)
MJO LPT = 0.28 mm/day (10%)

Tropical mean = 3.81 mm/day
LPT = 1.18 mm/day (31%)
MJO LPT = 0.62 mm/day (16%)


West Pacific - monthly3
Maritime Continent - monthly3
LS
LPO
LPT
MJO
Remainder
Mean precipitation (mm)
ENSO index
Year
La Nina
El Nino

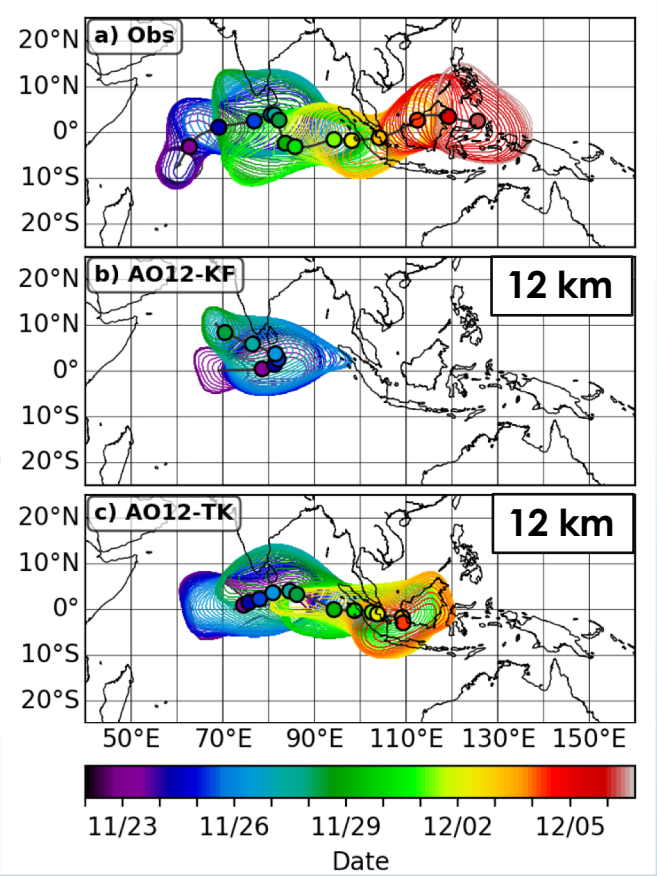
MAM Climatology	2011 (La Nina)	2015 (El Nino)
		
		
		
		
		

Coupled Atmosphere-Ocean Modeling



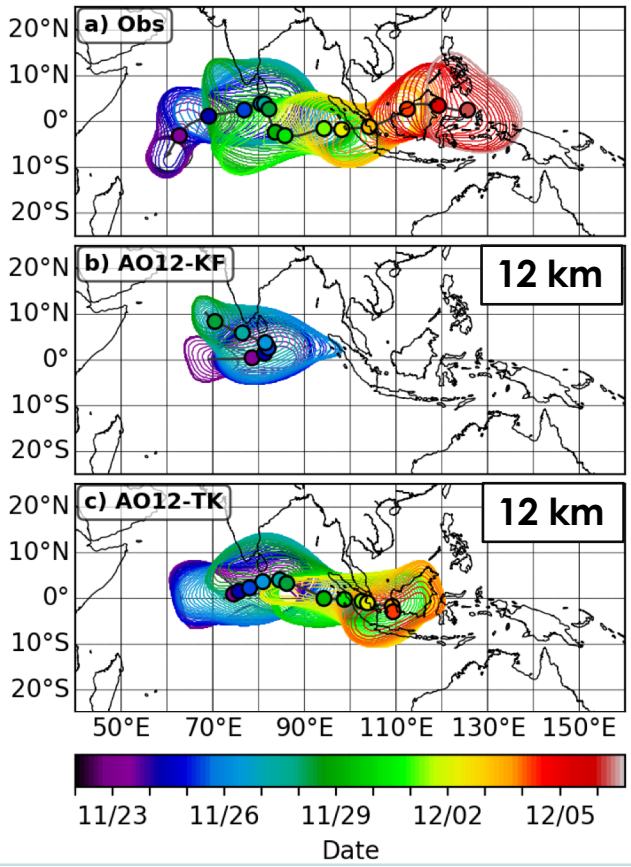
1) **Sensitivity to model resolution (parameterized v. explicitly resolved convection).**
2) **Effect of air-sea coupling on MJO prediction.**

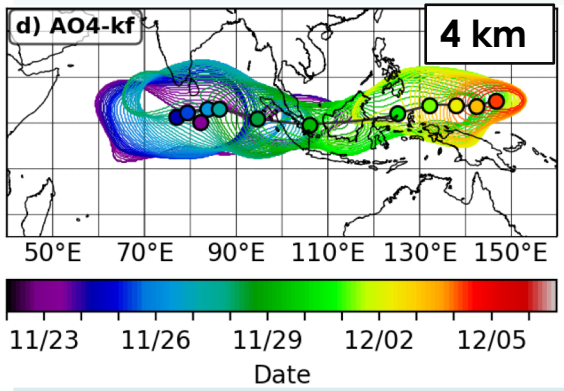
Sensitivity to Model Resolution (Savarin and Chen 2018a)



- Parameterized convection (at 12 km) does not reproduce the observed MJO, but some schemes are better than others.

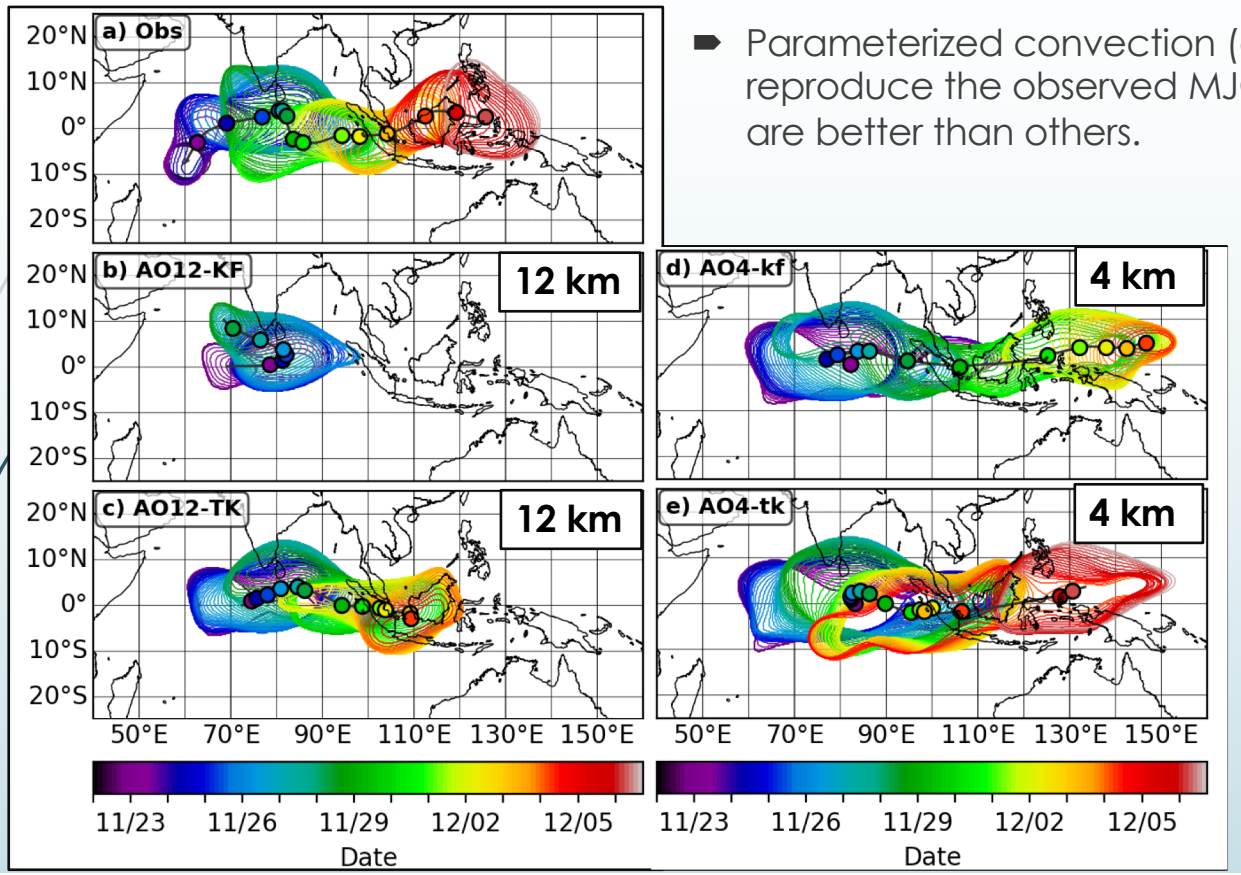
Sensitivity to Model Resolution (Savarin and Chen 2018a)





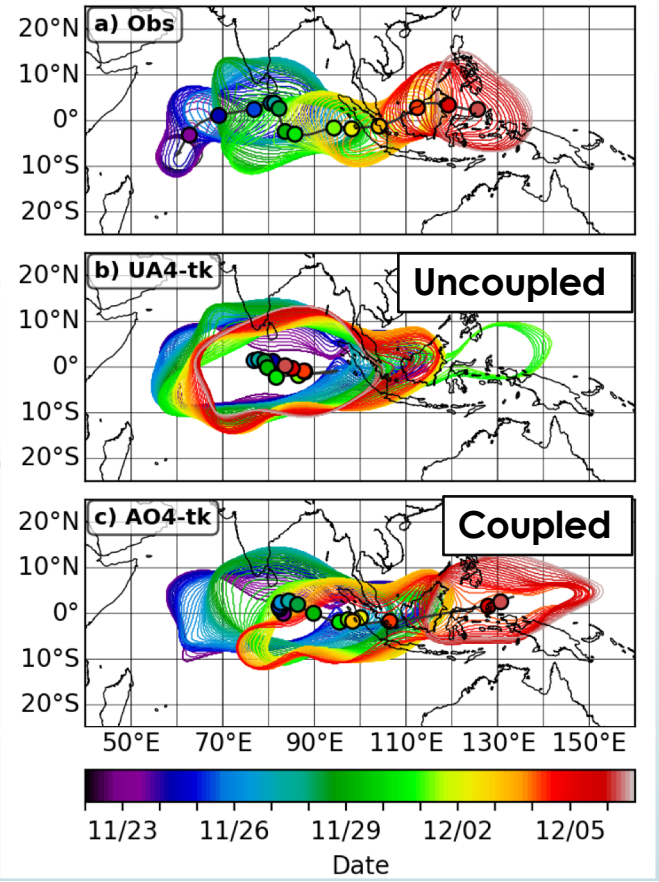
- Parameterized convection (at 12 km) does not reproduce the observed MJO, but some schemes are better than others.
- Explicitly resolved convection drastically improves the MJO prediction.

Sensitivity to Model Resolution (Savarin and Chen 2018a)



- Parameterized convection (at 12 km) does not reproduce the observed MJO, but some schemes are better than others.
- Explicitly resolved convection drastically improves the MJO prediction.
- Results vary depending on the lateral boundary conditions.

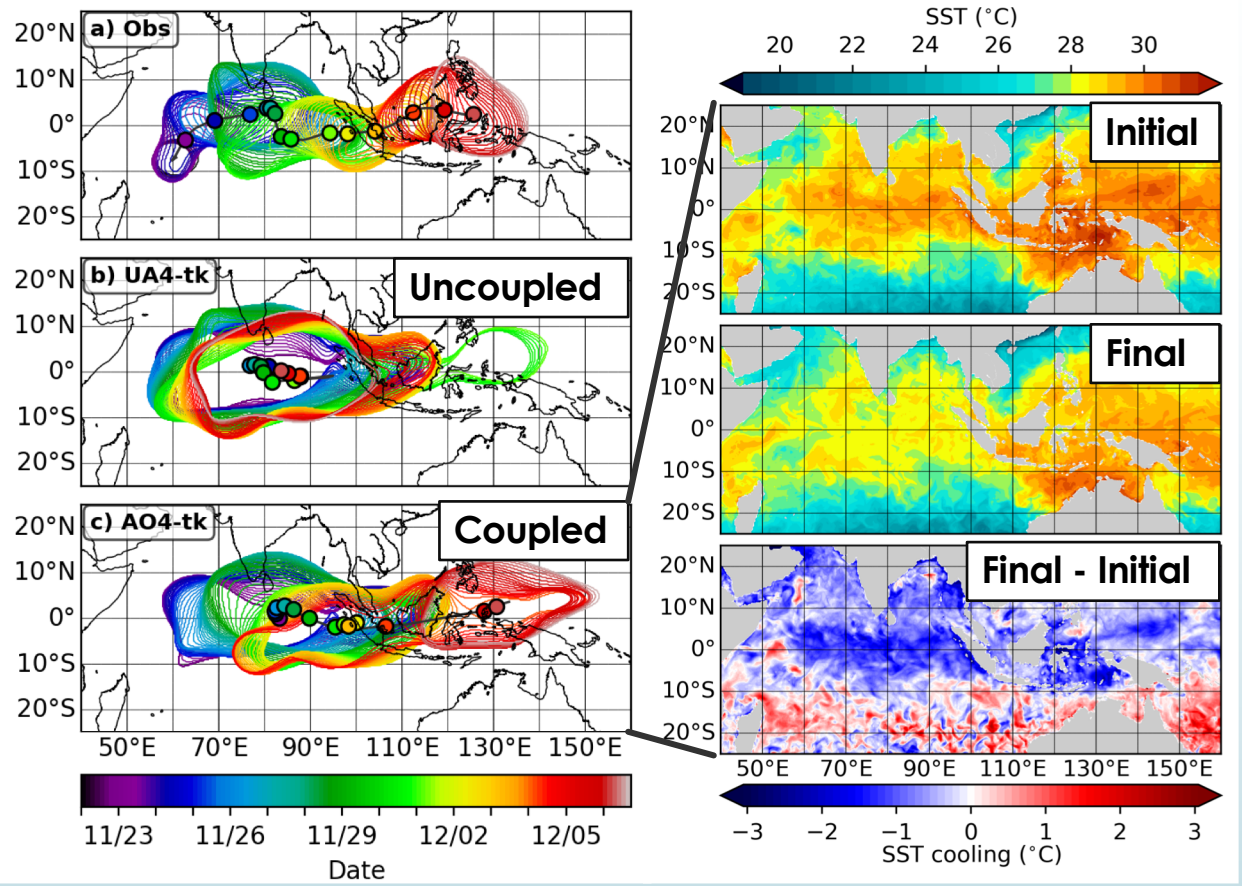
Impact of atmosphere-ocean coupling



(Savarin and Chen 2018b)

- Uncoupled model produces stationary "MJO". Coupled model produces clear eastward propagation, as observed.

Impact of atmosphere-ocean coupling



- Uncoupled model produces stationary "MJO". Coupled model produces clear eastward propagation, as observed.
- Reason for this difference is the SST cooling induced by the MJO.

SUMMARY

- **Large-scale Precipitation Tracking (LPT) provides a robust and direct measure of MJO convection, which can capture the spatial structure and its variability**
- **TRMM-GPM (TMPA) data provides an unique MJO climatology database for weather and climate research**
- **MJO impacts global weather downstream, which is key for subseasonal-to-seasonal (S2S) prediction, and a source of predictability.**
- **LPT can be used for verification of MJO prediction in both global and regional models**
- **Higher resolution and atmosphere-ocean coupling improve MJO initiation and its eastward propagation.**